Independent Peer Review of the Common Thresher Shark (*Alopias vulpinus*) Stock Assessment

Independent Peer Review Report for the Center for Independent Experts (CIE)

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1. Executive summary

The Fisheries Resources Division (FRD) of the Southwest Fisheries Science Center (SWFSC) requested an independent review of the stock assessment of the common thresher shark (*Alopias vulpinus*) from the west coast of North America. The stock is described to range between the west coasts of Mexico, USA and Canada. There are no current or historical fisheries along the west coast of Canada and in international waters that target common thresher sharks. Bycatch from other fisheries appear to be rare. Common thresher shark fisheries in both the USA and Mexico have declined substantially since the start of commercial fisheries in the 1970s, with total removals estimated to be <200 t in 2014. The current USA fishery management plan for this stock includes a harvest guideline of a maximum of 340 t derived from the optimum yield for vulnerable species (0.75*MSY).

The Stock Assessment Review Panel met at NOAA's Southwest Fisheries Science Center in La Jolla, California, from 26-28 July 2017 to review a stock assessment of common thresher shark.

This is the first stock assessment of common thresher sharks along the west coast of North America that incorporates information from all fisheries known to be exploiting the population. The Stock Synthesis (SS) modeling platform was used to conduct the analysis. The model began in 1969, assuming the population was at equilibrium prior to 1969 in a near un-fished state, and ended in 2014, which was the last year that data was available.

The main uncertainty identified in the stock assessment was the reproductive biology of this stock. Previous research suggested that female sharks had an age of maturity of 5 years and an annual reproductive cycle. The review scrutinized the evidence for this and found that potential misidentification of pelagic with common thresher sharks and problems in determining maturity stage in some of the original studies, pointed to a more likely older age of maturity (age 12) and possibly a biennial reproductive cycle. This would be consistent with recent studies for the same species in the Atlantic. Additionally, another previous study from the Indian Ocean that also showed that common thresher has an age of maturity of 5 years and an annual reproductive cycle was also analyzed during the meeting, and a similar problem in species identification (misidentification between pelagic and common threshers) was also found. On this issue, a recent IOTC (*Indian Ocean Tuna Commission*) working paper was provided by the reviewers addressing precisely this issue. Therefore, the stock assessment review agreed that there was sufficient evidence to use the late age at maturity life history parameters.

Those changes in the reproductive biology were found to be the major source of uncertainty in the models. Therefore, a sensitivity analysis using this final reproductive schedule was carried out, mainly in using different combinations of natural mortality and parameters from the stock-recruitment function (Zfrac, from the relatively new low-fecundity stock-recruitment function). In general, using those different combinations resulted in differences in the scale of the estimated populations, but most of the scenarios determined consistently similar stock status, i.e., that the stock was not overfished and that overfishing was not taking place. Therefore, the stock status determination was considered to be robustly estimated, with a conclusion that the current management harvest guideline of 340t seems to be adequate according to the US guidelines for fisheries management of vulnerable species (0.75*MSY).

The other aspects of the assessment were agreed to be based on the best available science and carried out in an un-biased and comprehensive way. The assessment model configuration, catch assumptions, and input parameters (e.g., natural mortality, spawner-recruit relationship) were reasonable. The models were appropriately configured, assumptions were reasonably satisfied, and primary sources of uncertainty were well accounted for.

The review process was effective in structuring a critical review of the work of the SWFSC and in identifying areas of concern and needs for additional work in future assessments. Some particular recommendations for future work were listed. The main one was regarding the main axis of uncertainty of the current assessment model, in particular the need for continuing biological studies to further investigate the reproductive biology of this population, especially in terms of the size at maturity, age at maturity, and reproductive cycle/periodicity.

2. Background

2.1. Introduction

The Fisheries Resources Division (FRD) of the Southwest Fisheries Science Center (SWFSC) requested an independent peer review of the stock assessment for the common thresher shark (*Alopias vulpinus*) from the west coast of North America. The stock is described to range between the west coasts of Mexico, USA and Canada. The common thresher shark fisheries from USA and Mexico are independently managed by the Pacific Fishery Management council (PFMC) and the Instituto Nacional de Pesca (INAPESCA), respectively. There are no current or historical fisheries along the west coast of Canada or in international waters that target common thresher sharks. Bycatch from other fisheries appear to be rare. Common thresher shark fisheries in both the USA and Mexico have declined substantially since the start of commercial fisheries in the 1970s, with total removals estimated to be <200 t in 2014. The current USA fishery management plan for this stock of common thresher sharks includes a harvest guideline of a maximum of 340 t derived from the optimum yield for vulnerable species (defined as 0.75*MSY).

This is the first stock assessment of common thresher sharks along the west coast of North America that incorporates information from all fisheries exploiting the population. The Stock Synthesis (SS) modeling platform was used to conduct the analysis. The model began in 1969, assuming the population was at equilibrium prior to 1969 in a near un-fished state, and ended in 2014, which was the last year that data was available. The stock assessment considered this population to be a single, well-mixed, trans-boundary stock and relied heavily on data from both the USA and Mexico. However, it is important to note that the analysts who reconstructed the catch time series for Mexico's fisheries were not available for the peer review meeting. A key uncertainty highlighted in the stock assessment is the reproductive biology of this stock of common thresher sharks. Previous research on this stock of common thresher shark suggested that female sharks had an age of maturity of 5 years of age and an annual reproductive cycle. However, a recent study on the reproductive biology of the western North Atlantic stock of common thresher sharks demonstrated a much older median age of maturity (age-12) and longer reproductive cycle (biennial or triennial cycle). Sensitivity model runs indicated that changing the maturity and periodicity/fecundity schedules resulted in differences in the trend and scale of the estimated population dynamics, but is in general to be used for the estimation of stock status.

The stock assessment provides the basis for scientific advice on the status of common thresher sharks along the west coast of North America. An independent peer review of the assessment is therefore essential. The Terms of Reference (ToRs) of the peer review are given below. Supporting documentation for the common thresher shark assessment was prepared by the SWFSC.

2.2. Description of Reviewers roles

The Stock Assessment Review Panel met at NOAA's Southwest Fisheries Science Center in La Jolla, California from 26-28 July 2017 to review a stock assessment for Common Thresher Shark (*Alopias vulpinus*).

The Stock assessment work and presentations were provided by Steve Teo (SWFSC). Other SWFSC scientists provided additional presentations and contributions, particularly Suzanne Kohin on the reproductive biology. Other participants from the SWFSC that were present and provided additional inputs were Kevin Hill, P.R Crone, Hui-Hua Lee, Helena Aryafar, Antonella Preti and Heidi Dewar.

The CIE Review Panel was composed by Henrik Sparholt (Denmark, Review panel Chair), Joseph Power (USA) and Rui Coelho (Portugal). There was no formal separation of the independent Reviewers roles as all contributed to all points of the agenda and the discussion. The Review Panel Chair coordinated the preparation of the summary report, and all other Reviewers provided contributions and revisions to the final summary report.

3. Summary findings for each TOR

3.1. ToRs item # 1

The item # 1 of the ToRs requested an "*evaluation of the assessment model configuration, assumptions, and input parameters (e.g., natural mortality, spawner-recruit relationship, reproductive biology) to determine if the data are properly used, input parameters are reasonable, models are appropriately configured, assumptions are reasonably satisfied, and primary sources of uncertainty are accounted for*".

Most of the time spent during the meeting was on this point of the ToRs and agenda. The main items discussed were in terms of model configuration, assumptions and input parameters.

Those are described in detail bellow:

3.1.1. Stock definition

The current stock assessment assumes the population to be a single stock, relying mainly on data from the USA and Mexico. The discussion on this issue was relatively limited as the current evidence seems to support this single stock hypothesis, including genetics and tagging data. The panel agreed that there seems to be sufficient current information to assume this stock definition as was used in the current stock assessment.

3.1.2. Catch history data

It was noted that several assumptions had to be made on the catch history time series, especially as for the initial years there were very limited data and details in species-specific catch composition. In general, it seems that the work that was done on the catch reconstruction seems adequate.

One specific case that was noted and raised some possible concerns was the artisanal Mexican fishery (*pangas*). This fishery is composed of very small boats that can use several artisanal gears, and the number of boats operating is very large (around 2000). It was noted that from those, only a minority have licenses to fish for sharks. One concern from the panel at the meeting was that this large number of vessels without shark licenses could also be by-catching sharks that had to be discarded due to the vessels not having specific shark licenses. As the shark discard and post-release mortality is likely very high, this could be a very important source of fishing mortality not accounted for in the current catch history (as the catches are estimated from landings, but do not account for possible discard mortality).

This issue was discussed at the meeting, but unfortunately the analysts who reconstructed the catch time series from Mexico were not available to be present at the meeting. However, the modelers explained that the Mexican data is actually coming also from market sampling and not necessarily only from port sampling, and there is likely very little discarding in those fisheries. So, the market sampling should cover well the overall catch and there shouldn't be too much discarding in this fishery for this to be an issue. The panel understood this explanation and agreed that the catches used likely represent the best available information at this stage. However, it was also recommended to further explore this issue, as this fishery could represent some additional source of mortality not currently accounted for.

3.1.3. CPUE standardization

The CPUE standardization method was briefly described and the main methods and results shown. The method used was the same for all CPUE time series data, specifically GLMs with a Delta lognormal approach (combination of a binomial model for modeling the probability of a set being positive, and a lognormal model for the expected CPUE conditional to the set being positive). The panel agreed that this is a commonly used and widely accepted method in commercial fisheries CPUE data standardization. The method is particularly useful when a certain proportion of the data is composed by zeros.

One specific comment made on the CPUE standardization was related with the distribution used. Currently the data is being modeled in catch numbers (N, discrete distribution), then transformed into a continuous variable (log (N)) to make it possible to use the lognormal distribution (continuous distribution). It was suggested, in the future, to possibly test other approaches, for example, to model the catch directly in numbers using a discrete distribution (i.e. the Negative Binomial, possibly with zero inflation if needed). Other possible alternative is the Tweedie distribution (generalization of the exponential family) that can model the mass of zeros and the continuous component for the positive sets in the same model. Those changes are unlikely to have a major impact in the CPUE series but it would be interesting to also test for those alternative approaches.

Another specific comment was made on the fact that the index from the main fishery (USDGN) had to be broken into 3 separate time series due to changes in regulations, with a period in the middle of the time series without information. The panel recognized and accepted that this had to be done because of the difficulty of modeling those changes in regulations in the GLM models, as there is no overlap of the different regulations in time and therefore the model cannot estimate parameters for those effects. However, by having to break the time series from the main fishery in 3 different sections, the overall contribution of those time series to the assessment model was also lower (except for S2 that still contributed significantly), and likely increased the variability within each section. The panel suggested that, in the future, a new attempt could be tried for the entire time series combined, trying to account for the changes in management regulations (mainly seasonal and spatial closures) as detailed spatial and seasonal effects in the GLM.

Finally, the group discussed the use of proxies for targeting variables in the models, in this case based on the rankings of swordfish catch within each year (used as categorical variables as a proxy for targeting swordfish *versus* sharks). One possible issue that was raised regarding this method is that if within specific years there is consistently the same targeting for the same species (e.g., swordfish), there will still be categorization and ranking within each year not necessarily consistent with the overall variations in the targeting of the fleet (inter-annually). This means that the targeting variable would no longer be comparable between different years. One possible suggestion by the panel to address this issue in the future would be to test and consider interactions between year and targeting effects.

3.1.4. Biological information

Biology, especially the reproductive biology, was agreed by the panel to be likely the major source of uncertainty in the stock assessment. The original stock assessment considered the hypothesis of a more productive biology based on a smaller size at maturity and annual fecundity. However, since then, there have been concerns about the original biological studies in the Pacific, with the new hypothesis that size at maturity could be larger (more similar to the one described for the Atlantic) and periodicity could be biennial.

The main issues identified with the original biological studies can be related with eventual species misidentification in threshers (between common and pelagic thresher), an issue that is now also suspected in some of the original studies in the tropical Indian Ocean. As pelagic thresher is a much smaller species, the size at maturity is also smaller and if there is misidentification this will have a great impact in the estimation of the size at maturity. There may have also been some issues with the original measurements from the observers.

It should be noted that an expert on shark biology from the Indian Ocean was contacted by e-mail during the meeting (E. Romanov) that was also involved in some of the original biological studies in that Ocean. This expert confirmed that the original studies in the tropical Indian Ocean were also likely misidentifying common and pelagic thresher, and therefore the calculation of the size at maturity is likely also incorrect.

The panel therefore fully agreed with this new hypothesis of the biology that is now posed by the SWFSC scientists of a larger size at maturity (also corroborated for the Indian Ocean) and possibly a biennial reproductive cycle. However, using this new biology created some additional convergence problems in some of the models that in general needed lower values of natural mortality (M) to converge. This issue was explored at great length during the meeting with the SWFSC modeler exploring multiple scenarios (especially combinations of M and Zfrac from the stock-recruit function) to investigate which combinations had problems of convergence, likely caused by conflicts in the data (CPUE, size data and biology). The panel agreed that the uncertainties in the reproductive biology of the common thresher shark in the Pacific are a source of major uncertainty in the stock assessment model and should be further studied.

Another minor detail noted is that the current model is using age at length data to estimate growth parameters inside the actual stock assessment model. Another option posed would be to use the parameters from an externally fitted growth model (using the same data) as fixed parameters in the SS model. The modelers explained that by allowing the stock assessment SS model to also estimate growth provided more flexibility to the biology and resulted in overall better fits. It was also noted that the parameters estimated in the SS were very similar to the externally obtained growth parameters, so this is not likely a major issue in terms of the stock assessment model.

3.1.5. Low fecundity stock-recruitment function

The stock recruitment function used in the final assessment was the one developed recently for low fecundity species like sharks. Within this function, the parameter Zfrac defines the slope of the stock-recruitment curve at the origin, i.e., the maximum recruitment rate produced when stock sizes approach very low values. This is conceptually very similar to the steepness (*h*) parameter of the Beverton-Holt stock-recruitment function, more commonly used in stock assessments.

The main issue discussed is that similarly to the steepness (*h*) parameter when using the Beverton-Holt function, there is usually also very little information in the data to actually estimate Zfrac. And, therefore, in a similar way to *h*, the values of Zfrac often have to be fixed (not estimated) and tend to be very influential in the stock assessments. This issue was explored at great length with the use of sensitivity analyses with various hypothesis and combinations of values.

In general, the use of this new low fecundity relation seems to be adequate for sharks. But it was also noted by the panel that any other form of the stock-recruitment function that have rapid declines at the origin (i.e., low stock size) should also be adequate for sharks, especially species like threshers that have very low productivity, mainly because of their very low fecundity. Some suggestions of other stock-recruitment functions with those characteristics were made, as for example a simple hockey stick with the recruitment constant over stock size until it reaches a threshold at which it declines linearly to the origin.

The panel agreed that this function and others with these same characteristics (i.e., steep decline at low stock size) would likely have produced similar results in the stock assessment results. And it should be further noted that alternative Beverton-Holt functions were used as sensitivity analysis (with the corresponding *h* value) and showed very similar results to the use of this new low fecundity stock-recruitment function. Therefore, the panel agreed that the population dynamics and stock status of the common thresher is likely robust to the function used, as long as it maintains these types of characteristics at a low stock size. However, the panel also recommended that further testing with this function should be carried out in the future.

3.1.6. Natural mortality

As mentioned previously, once the new reproductive biology was decided (based on a larger size at maturity and possible biennial cycle) the natural mortality (M) needed to be adjusted. This happened because the low productivity by year per adult female would cause the stock to collapse even without any fishing effort, if M was assumed higher than 0.14. This is a similar situation to having values of lambda (λ) lower than 1 (in a population dynamics model in this case a Leslie matrix model) that would mean a collapsing population even without any fishing mortality. This was judged unrealistic in a population dynamics perspective.

A model sensitivity run where M was allowed to be estimated (not fixed) by the model gave very low values of M of about 0.03, which corresponds to a very high maximum age. M values of 0.04, 0.06 and 0.08 mean that 1% of the stock in case of no fishing would be about 115, 77 and 58 years old, respectively. Based on the meta-analysis of M's relation to age at first maturity and to maximum age, the lower 95% confidence interval was 0.06. Runs with M equal 0.6 and 0.8 (and Zfrac varying between 0.6-0.9) made the models able to converge and not deviate much from each other in terms of model performance. The panel agreed that a maximum age of 58 years was more realistic than 77 years for this species, and therefore tentatively decided on that value for a new base run.

However, runs with M=0.08 and Zfrac=0.8 gave problems with internal consistencies of the model and data (conflicts between biology, CPUE information and size structure). Therefore, M had to be fixed at 0.04 and Zfract at 0.5 before these inconsistencies were solved. After long discussions, it was agreed to use this run as the best description of the stock dynamics and status, as the base run. This decision was reached knowing that it meant that M was outside the range indicated by the meta analysis of maximum age and age of maturity, meaning that there would be a very substantial number of very old fish in the plus group (25+). While this could be possible, at this stage it is unknown if that really is the case and where such part of the population would be located (spatially, seasonally and possibly in terms of depth habitat). Another issue was that such a low M would result in a very high maximum age of 115 years. Still, and even though there were those issues that remained to be addressed, this final scenario was regarded as the best compromise between the conflicting signals in the data and knowledge about the reproductive biology and corresponding population dynamics of this population.

3.2. ToRs item # 2

The item # 2 for the ToRs requests to "*evaluate the ability of the model, combined with available data, to assess the current status and productivity of common thresher sharks along the west coast of North America*"

It was agreed that the final base case model at the end of the meeting, that combines the currently available data and most likely hypothesis on the biology and population dynamics (larger size/age at maturity and possibly a biennial reproductive cycle), is able to currently and robustly assess the current stock status of common thresher shark. Both the review panel and modelers agreed that it would be better to use the most likely biological parameters (particularly the higher size/age at maturity that seems to be more likely) even if the model fitting was worse under those scenarios. The reasoning was that the best biological information should be used to inform as correctly as possible the population dynamics of the stock, recognizing the consequence of added uncertainties in natural mortality, maturity, gestation and reproductive cycle.

Nevertheless, both the review panel and modelers at the end were confident that the stock status determination was robust to those scenarios, and that the current stock size is above the MSY-related limits established in the US management system. All the uncertainties raised and detailed above (point 1 of the ToRs) are important, but after multiple sensitivity model runs it was determined that, in general, the model was robust in terms of the stock status determination and productivity. This means that even with the uncertainties mentioned before, the conclusions on the current stock status is consistent. The trajectories in biomass and fishing effort were very consistent in showing that stock sizes declined rapidly in the early years due to high fishing effort and catches. When the effort and catches were reduced, the stock started to recover and is currently neither overexploited nor experiencing overexploitation. The main difference in the various biological hypothesis and life history parameters was in the timing and speed of the recovery. However, several research recommendations were made for work that might further improve the model in the future, that are specified in detail below (see item 4 of the ToRs, below).

The panel cautioned that the uncertainties in life history, especially reproductive biology, and the implications for the stock-recruitment relationship are large. Therefore, projections of stock size using the current assessment and stock-recruitment model will be extrapolating beyond the data and will also be very uncertain. Therefore, and as a conclusion, while the panel is confident that the stock status is robust (i.e., stock not currently overfished nor undergoing overfishing, according to the MSY-related limits established in the US management system) the panel is also less certain about future projections and catch strategies or effort that would be required to achieve MSY related targets. If management were to pursue a policy of MSY targets, then the ability to precisely determine the strategy to achieve this would be severely limited by uncertainties in the basic biological information, as noted before. However, under current catches, the stock status seems to be robust.

3.3. ToRs item # 3

The item # 3 for the ToRs requests to "*evaluate the adequacy of sensitivity analyses to represent the main axes of uncertainty in the assessment*".

It was clear to all that the main axis of uncertainty on the final agreed base case model was the reproductive biology, and specifically the reproductive cycle/periodicity. In terms of management advice, the sensitivities were therefore mainly concentrated on this issue. It was agreed by all the participants that this approach was correct.

Currently the base case model assumes a two year reproductive cycle, and this reproductive periodicity is currently the most uncertain parameter and that is also likely contributing to most of the differences in the population dynamics of the species. Therefore, a strong recommendation to further continue work on the reproductive biology of this species was made (see item 4 of the ToRs, below). Other components that were also recommended for further testing were the stock-recruitment function and natural mortality (M).

3.4. ToRs item # 4

The item # 4 for the ToRs requests for "*recommendations for future research priorities and further improvements to the assessment model*".

There was general agreement between the review panel and stock assessment scientists on the recommendations for future research. Specific recommendations for future research were:

- <u>Juvenile shark surveys</u>: The survey design and protocols of the USA juvenile thresher shark survey should be reexamined and improved. Such surveys could bring important additional information to future stock assessment models. In this case, while there was data from the juvenile survey and a CPUE standardization procedure, the standardized CPUE from this survey was not actually used in the assessment. The reasons presented for this are that the location and timing of the sets were determined by the captain, with some of the initial sets used as learning sets, in a way somewhat similar to commercial fisheries operations. There were also issues with non-standardized soaking times, that was later tried to be taken into account as part of the effort in the standardization procedure. With the information and limited local knowledge I have on this specific survey, I cannot provide very specific details on how to possibly improve the survey. But the general idea, and in order for such survey to be more representative of the juvenile thresher shark abundance, it would be important to be designed in as much a fishery-independent approach as possible, with some type of randomized sampling locations, possibly depth and seasonally stratified, and using consistent operations and methods through time. The local NOAA researchers involved in such survey and familiar with the specific conditions and logistics are the ones better suited to improve the specific methods in this particular case;

- <u>Catch and catch-at-size data</u>: Both catch and catch-at-size estimates from USA and Mexico fisheries should be improved. The main priorities would be the Mexico fisheries and also the USA recreational fishery. The catch history of bycatch species, including most shark species, is usually one of the major uncertainty sources when conducting stock assessments. Often, this is an unknown and unaccounted source of uncertainty that is not considered, given that historical catches are usually point values given without any associated uncertainties. Even if there are now better established programs to record catch, effort and size distributions of the fisheries, the historical catches are still usually very poorly know for the bycatch species. In such cases, there is the need to reconstruct the historical catches to some degree. There are a number of ways to do this including, for example, statistical methods (e.g., GLM or GAM models to estimate past catches based on a series of covariates) or methods based on ratios of target/bycatch species. In such bycatch species with limited historical catch information, it is usually recommended to try to reconstruct the catches based on various hypotheses, and then test those within sensitivity model runs;

- <u>Size data/samples</u>: size samples seemed adequate from some fisheries (e.g., USDGN) but very limited in others, especially for the US recreational (USREC) and the Mexico fisheries (MXDGN and MXLL). Especially in those cases with very limited information, there was the need to assume similar size structure (i.e., similar selectivity) to some of the other fisheries with more information. This might be an important source of uncertainty in the current model and as such it was recommended for more effort to be put in collecting size data from those fisheries, preferably with sex-specific information. The improvement in the size/sex samples could be accomplished by a variety of methods, all with different characteristics and caveats that need consideration. The best way to improve data collection is specific to each fishery and fleet, and the local researchers familiar with the fleets are better suited to know which are the preferred methods. Some traditional approaches for consideration are:
    - Scientific onboard observers: This is usually the preferred method and the one most likely to capture the entire size distribution of the catches from each fleet. The drawbacks are usually high costs, and possible logistics issues of having observers in smaller vessels with limited space and conditions;
    - Port sampling: this is usually a cost-effective way to sample the size distribution of the landings. The main drawback is that it is not possible to sample discards, both in terms of discarded species and discarded sizes. Threfore, great care needs to be used when using only port-sampling information to study the species composition and size distribution of a fishery;

  - Self-sampling programs: those are programs where fishing skippers and crews are trained to voluntary record the size distribution of the catch during the fishing operations. If properly established, those programs can usually provide a good coverage of the size distribution, that can include both retained and discards, at least for the main targeted species. Establishing and maintaining the quality of such programs implies a strong relation between the researchers with the fisheries sector;

- <u>Low fecundity stock-recruitment relationship</u>: The use of the relatively new low fecundity stock recruitment relationship seems appropriate for sharks in general, and particularly for Lamniformes as the common thresher that have some of the lowest fecundities even within sharks. However, this low fecundity stock recruitment relationship is relatively new and has not yet been fully tested, and requires further research. The stock status of common thresher seemed to be robust to this issue (as tested with sensitivity analysis), but it would be recommended to test other options (e.g., a hockey stick model or any other function that allows for rapid drops at very low stock sizes);

- <u>Reproductive biology</u>: The current lack of knowledge and uncertainties associated with the reproductive biology is likely the main cause of uncertainty in the stock assessment model. While most cases and sensitivities tested with the various hypotheses do not affect the stock status, in some cases there are problems of data conflicts in the model that needs further exploration. As such, it is <u>highly recommended</u> to continue the biological studies to further investigate the reproductive biology of this population, especially in terms of the size at maturity, age at maturity, and reproductive cycle/periodicity. It is also noted, however, that while parameters such as size/age at maturity should be relatively simple and feasible to study, the reproductive cycle (periodicity) will likely be much more difficult to fully study due to the need to have access to large number of samples (mature and pregnant females) over all seasons and with detailed reproductive data;

- <u>CPUE standardization</u>: While the overall CPUE standardization process seemed to follow the current practices in fisheries, especially with large pelagics, there were some issues that could be the focus for future work and research. Specifically, it was recommended to test some alternative distributions (e.g., Negative Binomial for count data or Tweedie for continuous data with a mass of zeros), consider and test the inclusion of interactions, test the possibility of modeling the USDGN as a single time series (using detailed spatial and seasonal effects to try to account for spatial/seasonal changes in management), and consider using vessel effects as a random variable to add variability associated with different vessels of the fleet.

3.5. ToRs item # 5

The item # 5 for the ToRs requests for a "*brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations*".

It is very important to note that the entire meeting was very productive and always carried out in a much positive atmosphere.

The SWFSC scientists, especially the modeler Steve Teo, was very supportive and skillful in providing the panel with several extra assessment model runs and plots of selected diagnostics in a speedy and very efficient way during the meeting and in the evenings between the meeting days. The panel appreciated and thanked all the support and positive atmosphere, as well as the immediate willingness of the modelers to test and consider all the alternative approaches and scenarios hypothesized.

Appendix 1: Bibliography of materials provided for review

Documents provided for review prior to the meeting

Aryafar, H., Preti, A., Dewar, H., Kohin, S. 2017. Re-examination of the reproductive biology of common thresher sharks along the west coast of North America. Fisheries Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Drive, La Jolla, CA 92037, USA.

Teo, S.L.H.; Rodriguez, E.G., Sosa-Nishizaki, O. 2016. Status of common thresher sharks, *Alopias vulpinus*, along the west coast of North America. NOAA-TM-NMFS-SWFSC-557.

Stock Synthesis model files and other related assessment information published in the interim that were provided by the SWFSC Project Contact (Steve Teo).

Additional documents provided during the meeting both by the review panel and stock assessment analysis

Anon. 2017. FAQs: West Coast drift gillnet (DGN) fishery & protected species. U.S. Department of Commerce, National Oceanic & Atmospheric Administration, National Marine Fisheries Service, West Coast Region.

Romanov, E. 2015. Do common thresher sharks *Alopias vulpinus* occur in the tropical Indian Ocean? IOTC Working Party on Ecosystems and Bycatch (WPEB). Olhão, Portugal.

Taylor, I.G., Gertseva, V., Methot, R.D., Maunder, M.N. 2013. A stock-recruitment relationship based on pre-recruit survival, illustrated with application to spiny dogfish shark. *Fisheries Research*, 142: 15-21.

Teo, S.L.H. 2017. Population dynamics of common thresher sharks along the West Coast of North America, assuming alternative reproductive biology and natural mortality parameters. Fisheries Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Drive, La Jolla, CA 92037, USA.

Appendix 2: Copy of the Statement of Work

Statement of Work

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Center for Independent Experts (CIE) Program

External Independent Peer Review

Status of Common Thresher Sharks, *Alopias vulpinus*,

along the West Coast of North America

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards.
(http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).
Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The Fisheries Resources Division (FRD) of Southwest Fisheries Science Center (SWFSC) requests an independent review of the benchmark stock assessment developed for the common thresher shark stock along the west coast of North America. The biological range of the stock spans the west coasts of Mexico, the United States of America (USA), and Canada. The common thresher shark fisheries of the USA and Mexico are independently managed by the Pacific Fishery Management council (PFMC) and the Instituto Nacional de Pesca (INAPESCA), respectively. However, there are no current nor historical fisheries along the west coast of Canada and in international waters that target common thresher sharks and bycatch appears to be rare. Common thresher shark fisheries in both the USA and Mexico have declined substantially since the start of commercial fisheries for this stock in the late 1970s, with total removals estimated to be <200 t in 2014. The current USA fishery management plan for this stock of common thresher sharks includes a harvest guideline of 340 t based on an unpublished analysis of USA data and is derived from the optimum yield for vulnerable species, which is defined as 0.75*MSY (or reasonable proxy).

This is the first stock assessment of common thresher sharks along the west coast of North America that incorporates information from all fisheries exploiting the population. The Stock Synthesis (SS) modeling platform was used to conduct the analysis. The model began in 1969, assuming the population was at equilibrium prior to 1969 in a near unfished state, and ended in 2014, which was the last year that data was available. The stock assessment considered this population to be a single, well-mixed, trans-boundary stock and relied heavily on data from both the USA and Mexico. However, it is important to note that the analysts who reconstructed the catch time series for Mexico's fisheries will not be available for the peer review. A key uncertainty highlighted in the stock assessment is the reproductive biology of this stock of common thresher sharks. Previous research on this stock of common thresher shark suggested that female sharks had an age of maturity of 5 years of age and an annual reproductive cycle. However, a recent study on the reproductive biology of the western North Atlantic stock of common thresher sharks demonstrated a much older median age of maturity (age-12) and longer reproductive cycle (biennial or triennial cycle). Sensitivity model runs indicated that changing the maturity and fecundity schedules resulted in substantial differences in the trend and scale of the estimated population dynamics. The stock assessment provides the basis for scientific advice on the status of common thresher sharks along the west coast of North America. An independent peer review of the assessment is therefore essential. The Terms of Reference (ToRs) of the peer review and the tentative agenda of the meeting are below.

Requirements

NMFS requires a review chair who has a working knowledge and recent experience in the application of fisheries stock assessment processes and two (2) reviewers to conduct an impartial and independent peer review in accordance with the SoW, OMB guidelines, and the ToRs below. The Chair would ensure that reviewers understand the importance of the peer review process in accordance with the SoW, OMB Guidelines, and ToRs. In addition, the chair will be selected by the contractor and be responsible for facilitating the meeting.

The CIE chair shall serve as an external expert to chair the panel review and have excellent oral and written communication skills. In addition, the chair shall a have working knowledge, recent experience in the application of fisheries stock assessment processes, and results, including population dynamics, integrated statistical age-structured models like Stock Synthesis models and shark biology (reproduction and growth). The chair should also have experience conducting stock assessments for fisheries management.

The reviewers shall also have working knowledge, recent experience in the application of fisheries stock assessment processes, and results, including population dynamics, integrated statistical age-structured models like Stock Synthesis models and shark biology (reproduction and growth). They should also have experience conducting stock assessments for fisheries management. It is desirable for at least one of the reviewers to be familiar with shark stock assessments.

Tasks for reviewers

1) Review the following background materials and reports prior to the review meeting;

Teo, S. L. H., E. G. Rodriguez, and O. Sosa-Nishizaki. 2016. Status of common thresher sharks, *Alopias vulpinus*, along the west coast of North America. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-557. 196 pp.

Aryafar, H., A. Preti, H. Dewar, and S. Kohin. Reproductive biology parameters for common thresher sharks along the west coast of North America. Document to be developed.

Stock Synthesis model files and other related assessment information published in the interim that is provided by the SWFSC Project Contact.

2) Attend and participate in the panel review meeting. The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to answer any questions from the reviewers, and to provide any additional information required by the reviewers.

3) After the review meeting, reviewers shall conduct an independent peer review report in accordance with the requirements specified in this SoW, OMB guidelines, and ToRs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.

4) Each reviewer should assist the Chair of the meeting with contributions to the summary report.

5) Deliver their reports to the Government according to the specified milestones dates.

Specific Tasks for CIE Chair:

The following chronological list of tasks shall be completed in a timely manner as specified in the **Schedule of Milestones and Deliverables.**

1) Conduct necessary pre-review preparations, including the review of background material and reports in advance of the peer review;

2) Participate as the chair during the June 26-28, 2017 panel review meeting at the Southwest Fisheries Science Center in La Jolla, California, and facilitate the panel review maintaining the focus of the peer review in accordance with the ToRs;

3) Produce a Summary Report of the proceedings. The summary report shall not be a consensus report. The independent CIE reviewers should have an opportunity to review and provide comments or elaboration on any points raised in the summary report that they feel might require further clarification.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be at the contractor's facilities, and at the Southwest Fisheries Science Center in La Jolla, California, USA.

Southwest Fisheries Science Center
Pacific Room
8901 La Jolla Shores Drive
La Jolla, CA 92037
USA

Period of Performance

The period of performance shall be from the time of award through August 18, 2017. The CIE chair and each reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Within two weeks of award	Contractor selects and confirms CIE Chair and reviewers
No later than June 5, 2017	Contractor provides the pre-review documents to the CIE Chair and reviewers
June 26-28, 2017	Panel review meeting
No later than July 7, 2017	The CIE Chair submits a draft Summary Report to the contractor for each of the independent reviewers to review and comment
July 17, 2017	Contractor receives draft independent peer review reports as well as the reviewed draft Summary Report
July 31, 2017	Contractor submits final reports to the Government

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards:

(1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each TOR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $10,000.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

NMFS Project Contact:

Dale Sweetnam

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Deputy Director, Fisheries Resources Division
Southwest Fisheries Science Center

National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037
(858) 546-7170

Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.

   a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review

   Appendix 2: A copy of this Statement of Work

   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Terms of Reference for the Peer Review

Status of common thresher sharks, Alopias vulpinus, along the west coast of North America

1. Evaluate the assessment model configuration, assumptions, and input parameters (e.g., natural mortality, spawner-recruit relationship, reproductive biology) to determine if the data are properly used, input parameters are reasonable, models are appropriately configured, assumptions are reasonably satisfied, and primary sources of uncertainty are accounted for.
2. Evaluate the ability of the model, combined with available data, to assess the current status and productivity of common thresher sharks along the west coast of North America.
3. Evaluate the adequacy of sensitivity analyses to represent the main axes of uncertainty in the assessment.
4. Recommendations for future research priorities and further improvements to the assessment model.
5. Brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

Tentative AGENDA
2017 Common Thresher Shark (*Alopias vulpinus*)
Stock Assessment Review

Southwest Fisheries Science Center
8901 La Jolla Shores Dr., La Jolla, CA 92037
La Jolla, CA 92037
858-546-7000

This is a public meeting, and time for public comment may be provided at the discretion of the meeting Chair. This is a work session for the primary purpose of reviewing the current Common Thresher stock assessment, under the Center for Independent Experts terms of reference (ToR). The Stock Assessment Review Panel will review the assessment and produce independent reports and in conjunction with the Chair. The Stock Assessment Team (STAT) will provide presentations and all appropriate background information needed for the review.

MONDAY, JUNE 26, 2017

A. Call to Order, Introductions, Approval of Agenda — Chair
(10 a.m., 15 minutes)

B. Terms of Reference for Stock Assessment Review Process — Dale Sweetnam
(10:15 a.m., 15 minutes)

C. Common Thresher Stock Assessment — Steve Teo, STAT
(10:30 a.m., 1.5 hours)

LUNCH

D. Common Thresher Stock Assessment (Continued) — Steve Teo, STAT
(1 p.m., 2 hours)

BREAK

E. Discussion and Requests — Panel
(3:30 p.m., 1 hour)

F. ***Public Comment***
(4:30 p.m., 0.5 hours)

TUESDAY, JUNE 27, 2017

G. Response to Requests — Steve Teo, STAT
(8:00 a.m., 2 hours)

BREAK

H. Initial Report Writing and STAT Work Session — Panel
(10 a.m., 2 hours)

LUNCH

I. Discussion and Requests
(1:30 p.m., 1 hour)

J. Public Comment

(2:30 p.m., 0.5 hours)

BREAK

K. Report Writing and STAT Work Session Panel

(3:30 p.m., 2 hours)

WEDNESDAY, JUNE 28, 2017

L. Response to Requests Steve Teo, STAT

(8 a.m., 2 hours)

BREAK

M. Discussion and Requests Panel

(10:30 a.m., 1.5 hours)

LUNCH

N. Response to Requests Steve Teo, STAT

(1 p.m., 1 hour)

O. Public Comment

(2 p.m., 0.5 hours)

BREAK

P. Discussion – Next Steps and Deadlines

(3 p.m., 1 hours)

Q. Finalize Report Assignments Chair

(4 p.m., 1 hours)

R. Work Session as Necessary and Meeting Wrap Up Chair

(5 p.m.)

ADJOURN

Appendix 3: Panel membership or other pertinent information.

The following table provides the panel membership including the CIE reviewers and SWFSC scientists that carried out the assessment and made the presentations:

Name	Organization	Country
Henrik Sparholt (Chair)	CIE	Denmark
Joseph Powers	CIE	USA
Rui Coelho	CIE	Portugal
Suzanne Kohin	SWFSC	USA
Kevin Hill	SWFSC	USA
P.R. Crone	SWFSC	USA
Heidi Dewar	SWFSC	USA
Hui-Hua Lee	SWFSC	USA
Steven Teo	SWFSC	USA